BURSTING STRENGTH OF STANDARD PIPE FITTINGS

J. G. HATMAN
R. A. LEAWELL

ARMOUR INSTITUTE OF TECHNOLOGY

1910

BURSTING STRENGTH OF STANDARD PIPE AND FITTINGS

A THESIS

PRESENTED BY

JULIUS G. HATMAN
RICHARD A. LEAVELL

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING 5

MAY, 1910

BURSTING STRENGTH OF STANDARD PIPE AND FITTINGS.

The object of this series of tests was to compare the actual with the theoretical bursting strength of standard pipe and fittings.

The water pressure used in the tests was furnished by a Marsh direct acting steam pump, having twelve inch steam cylinder and oneinch water plunger, which should have been capable of a pressure of fourteen thousand pounds per square inch with a steam pressure of one hundred pounds. The first pump worked satisfactorily up to five thousand pounds but above that it leaked so badly that the limit was eighty five hundred. The gland blew out at that pressure and it was found that the packing had forced in between the gland and the rod so tightly that it was only with the aid of an arbor press that the rod was pressed out. Another water end of the pump was supplied by the manufacturers and was installed at once. It has delivered against a pressure of twelve thousand five hundred pounds.

Double extra heavy one inch piping, having an outside diameter of an inch and a quarter, and

andinternal of five eighths, was put up from the pump to the testing stand. The ells were made of two by two by two and one half inch blocks of mild steel, bored, threaded, and finish tapped, on the end and side in the lathe, The heavy piping was also threaded in the lathe, as the threads cut in the machine would not stand the pressure without excessive leakage. An angle needle valve was made and attached in the line beside the pump, its function being to prevent sudden fluctuations in pressure, and the too sudden release of pressure on the pump at the time of breakage of the specimen. The fittings were found to hold when screwed up without oil or lead.

A twelve inch gauge manufactured by the Crossby Steam Gauge Co., of Boston, Mass., and having a range of zero to fifteen thousand pounds was used to indicate the pressure. A bronze ball check valveserved to prevent injury to the mechanism when the pressure should be suddenly released, and a maximum needle adjustable to zero at will to indicate the highest pressure. It was connected to one half inch pipe

tapped into a coupling similar to the ells in the riser of the high pressure piping. The gauge, the heavy piping, and part of the pump are visible in the blue print page . One of the ells and a short nipple of the heavy piping are visible in the print on page 13.

The specimens were of standard mild steel pipe, all being taken from the stock of the forge shop except the five and six inch sizes which were purchased from Clow and Sons. The nominal diameters and the lengths of the specimens are shown in columns two and three of the log of test, page 15. The caps with two exceptions were taken from the stock of the forge shop. In all the sizes smaller than five inch, where possible two specimens of each size were tested. Special steel caps, bored out from the solid and threaded in the lathe, were made up that they might be strong enough to withstand the pressure necessary to burst the pipe. To save metal and time only two pairs of caps were made up, one pair being threaded for three and five inch pipe, the other for two, four, and six inch. One cut of each pair was bored, threaded, and finish tapped for the heavy hy-

draulic piping. Owing to difficulty in getting a good thread in one of the three and one of the four inch caps they were bored out and bushings made of standard couplings threaded in. The accompanying blue prints on pages and show thecaps.

When a specimen had been screwed up ready for test, blocks were placed against the caps at both ends to prevent danger of damage of injury in case of failure at the threads, and the pressure was applied until the needle on the gauge, by its vibration, indicated considerable leakage, when the pump was shut down, and the caps were drawn up againwith the chain tongs. After the second drawing up of the caps little trouble with leakage was encountered.

A discussion of the test by pipe sizes may give an idea of the results. On page will be found the results of the tests on the piping, and on page those on the caps.

There are shown the results of three tests on one inch pipe. The specimens had been in use for some time and were somewhat rusted.inside. The nominal diameters and lengths are

shown in the second and third columns of the log sheet. The thicknesses were measured on different diameters at the ends and near the fractures and the averages entered in the fourth column. The average results are shown at the bottom of the sheet. The pipe tore open in the weld for a length varying from three to seven inches, and in a position anywhere from the middle to right next to the cap. On the bottom and the right of the blue print are two of the specimens showing the appearance of the fractures.

Three one inch caps were broken and the results entered on the log sheet, page . Two of the fractures were longitudinal thru the threaded portion, and one was circumpherential just where the head joins the cylindrical portion of the cap. The blue print on page shows the appearance of one of the caps.

Three specimens of two inch pipe were tested and the results tabulated on the sheet. Two of the fractures are shown on the right on page .

One two inch cap was tested, the head

blowing off leaving a conical surface at an angle of about fourty five degrees with the surface. The thickness of the metal on the surface of rupture was measured in several places and the result averaged and entered in the fourth column. The bursting pressure over the whole area of the head of the cap was divided by this area of rupture to give an approximate value of the strength of the metal, and the result tabulated in the sixth column. The ratio of the bursting strength of the cap to that of the pipe was calculated and entered in the fifth column.

Three specimens of three inch pipe were tested and the results are on the sheets. Two of the specimens were from the same piece of pipe and both showed fractures about one hundred and teenty degrees from the weld. The appearance of the fracture would lesd one to conclude that there was much slag in the metal. The third specimen was not so rusty as, and was thinner than the first two. It broke kn the weld at a pressure somewhat smaller than would have naturally been expected from the slight differe

ence in thickness. The three specimens are shown in the blueprint on page

Three caps of the same size were tested, and all failed by blowing out. One showed results so high in connection with the thickness recorded that there must have been some error in observation, and the results have been neglected.

Two tests of four inch pipe were unsuccessful as far as bursting was concerned. The failure occurred in both cases at the root of the thread just behind the cap. rings being torn completely off. The tensile strength of the metal was calculated from the area in tension and the total pressure on the surface of the cap.

The five inch piece failed twice, the first time a complete ring being torn off, and the second only part of one. The rings torn off of some of the specimens and the end of the five inch piece are shown in the blue print, page .
The five inch piece stands upright at the left.

The six inch piece also failed at the root of the threads,,the piece having to be torn off.

The six inch cap was broken before the six

inch pipe. The failure was very similar to that of the smaller sizes. The Blue print, page shows this specimen.

The results on the caps are not very uniform, partly because cast iron is such an uncertain substance.

Tensile tests were made on pieces cut longitudinally out of pieces of the two, three, and four inch pipe, and the results tabulated on the sheet on page . Rings were cut out of the same pipe, opened up, part of them at the weld, and part opposite it, heated and straightened. These were also pulled in the Olsen machine, to give the tensile strength across the fibre as the stress comes in the pipe, and the strength of the weld. The percent elongations are all for eight inch test specimens except those of the transverse sections of two inch pipe. The rings of the three inch pipe were so badly rusted and pitted and the metal was such that it was only with the greatest difficulty that the rings could be straightened out. A ring of the four inch pipe was compressed in a vise

until it formed an ellipse with its major axis equal to twice its minor before it failed in the weld. The weld was very short for a lap weld, having almost the appearance of a but weld.

The tensile strength of a piece of pipe can be calculated, according to the Valve World of February 1905, from the diameter, the tensile strength, and the thickness. The bursting pressure is expressed by

$$B\,P = \frac{2\,T\,S}{D}$$

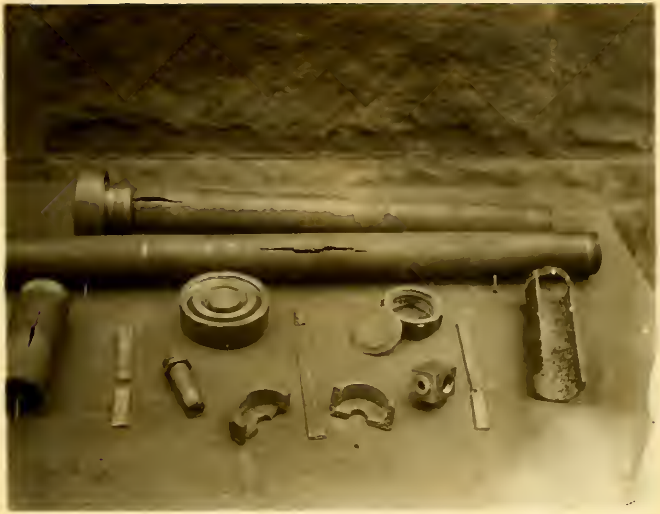
where B P = Bursting Pressure, pounds per square inch.

T = Thickness, inches.

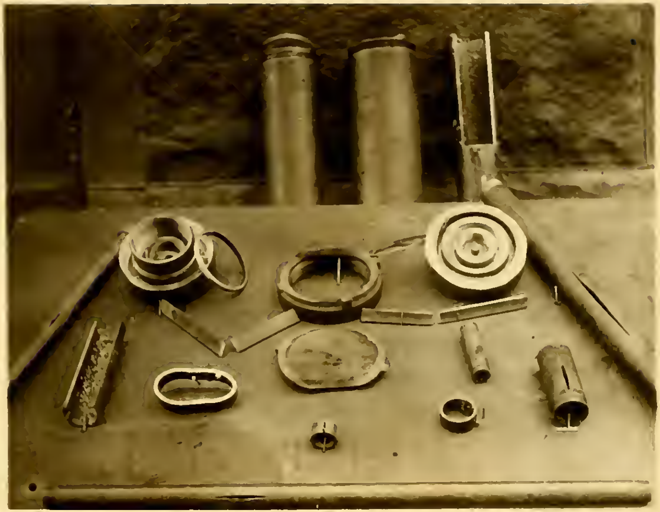
D = Diameter, inches.

S = Tensile strength, pounds per square inch.

The strength of the pipe tested was calculated from the thickness, with an assumed tensile strength of fifty thousand pounds, and with the transverse strength calculated from the tensile tests. These results were compared with those actually gotten in the test the ratio and the calculated strengths being tabulated.




6000
8000
10000
7000
9000



LOG OF TEST.

Test	DIMENSIONS			BURSTING STRENGTH #/SQ."			EFFICIENCY FROM TENSILE STRENGTH		
	Diam	Length	Thick-ness	Actual	Theoret-ical	Calcu-lated	Theoret-ical	Calcu-lated	Tensile Strength From Test
1	1"	4'-0"	.144	7800	14400		.542		
2	1"	4'-0"	.144	7700	14400		.535		
3	1"	4'-0"	.144	7700	14400		.535		
4	2"	4'-0"	.153	4950	7650	9560	.647	.518	
5	2"	2'-6"	.153	4800	7650	9560	.627	.502	
6	2"	3'-0"	.153	5500	7650	9560	.719	.575	
7	3"	4'-0"	.230	3500	7670	2720	.457		
8	3"	4'-0"	.230	3500	7670	2720	.457		
9	3"	3'-6"	.224	3000	7470		.402		
10	4"	4'-0"	.216	1800	5400	5330	.333	.337	6250
11	4"	4'-0"	.216	1700	5400	5330	.315	.319	5890
12	5"	5'-0"	.220	2500	4400		.568		7230
13	5"	5'-0"	.220	2600	4400		.591		7520
14	6"	5'-0"	.223	3200	3720		.860		7610
Average									
	1"		.144	7730	14400		.537		
	2"		.153	5080	7650		.664		
	3"		.228	3300	7655		.439		
	4"		.216	1750	5400		.324		
	5"		.220	2550	4400		.579		
	6"		.223	3200	3720		.860		

LOG OF TEST.

TEST	DIAM.	BURSTING STRENGTH	THICKNESS	RATIO CAP TO PIPE	STRESS IN METAL
1	1"	5500			
2	1"	5300			
3	1"	5700			
4	2"	4500	.1975		11450
5	3"	2950	.690		32100
6	3"	3750	.4575		61500
7	3"	3050	.690		34300
8	6"	2000	.6125		49000
Average	1"	5500		.711	[illegible]
	2"	4500	.1975	.875	11450
	3"	3000	.690	.91	35200
	6"	2000	.6125	.625	49000

TENSILE TEST OF SPECIMENS.

Pipe Diam	Section	Area sq."	Load	Tensile St'ngth	Elongation.%
4"	Longitudinal	.175	12550	71800	.172
4"	"	.1405	11500	82000	;250
4"	"	.180	13000	72100	.119
4"	Transverse	.189	9900	52300	.0125
4"	"	.2025	9200	46500	.0163
4"	" at weld	.180	11700	65000	.163
3"	Longitudinal	.232	10100	43100	.120
3"	"	.2205	8600	38800	.0875
3"	"	.207	8000	38600	.0937
3"	Transverse	.180	3200	17600	.0416
3"	"	.2161	3800	17950	.0400
3"	" at weld	.2022	2400	11800	.0170
2"	Longitudinal	.141	3550	60700	.213
2"	"	.1035	6100	59000	.197
2"	Transverse	.102	6100	59600	.0625
2"	"	.093	6050	65000	.080
2"	" at weld	.1125	4750	42200	.1128
2"	" " "	.1096	4750	43300	.1098
4"	Longitudinal	Average		75300	.183
4"	Transverse	"		49400	.0144
3"	Longitudinal	"		40160	.1004
3"	Transverse	"		17750	.0408
2"	Longitudinal	"		59850	.205
2"	Transverse	"		62300	.0712